THE COMMONWEALTH OF MASSACHUSETTS
OFFICE OF THE INSPECTOR GENERAL

Value Engineering:

A Review of a Central Artery/Tunnel Project Cost-Control Program

Robert A. Cerasoli
Inspector General
December, 1994

The Commonwealth of Massachusetts

Office of the Inspector General

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December 1994

His Excellency the Governor

The Honorable President of the Senate

The Honorable Speaker of the House

The Honorable Chairman of Senate Ways and Means

The Honorable Chairman of House Ways and Means

The Executive Directors of the Legislative Post Audit Committees

The Secretary for Administration and Finance

Members of the General Court

Omnibus ad quos praesentes literae pervenerint, salutem.

I am today releasing a report concerning the efforts of the Massachusetts Highway Department (MassHighway) through its management consultant, Bechtel/Parsons Brinckerhoff (B/PB), to control costs on the $7.7 billion Central Artery/Tunnel (CA/T) Project. Specifically, the report focuses on the process by which B/PB, acting on behalf of MassHighway, has managed the value engineering program. Value engineering provides an opportunity for MassHighway to simplify designs thereby controlling costs and reducing construction time. I have concluded that the value engineering program is flawed, not in concept but in execution.

The Commonwealth faces great challenges as it enters the construction phase of the CA/T Project. The potential for delays and cost overruns increases dramatically as the Project proceeds. The value engineering program recommended over $2.8 billion in potential savings. MassHighway, taking advantage of a small number of recommendations made in 1989, reportedly saved $325 million, a significant amount. Nonetheless, I believe that greater savings could have been realized.

In spite of the missteps, inadequate management, and poor planning documented in the report, significant opportunities still exist for controlling costs through value engineering without delaying the CA/T Project. For instance, the Fort Point Channel crossing is being

redesigned and the Charles River crossing design -- which replaces Scheme Z -- is in final design. The total estimated cost for the Charles River crossing alone is more than $1.6 billion. By revitalizing the value engineering program -- and avoiding the pitfalls documented in this report -- Project leadership could sharpen one of its key cost-control tools.

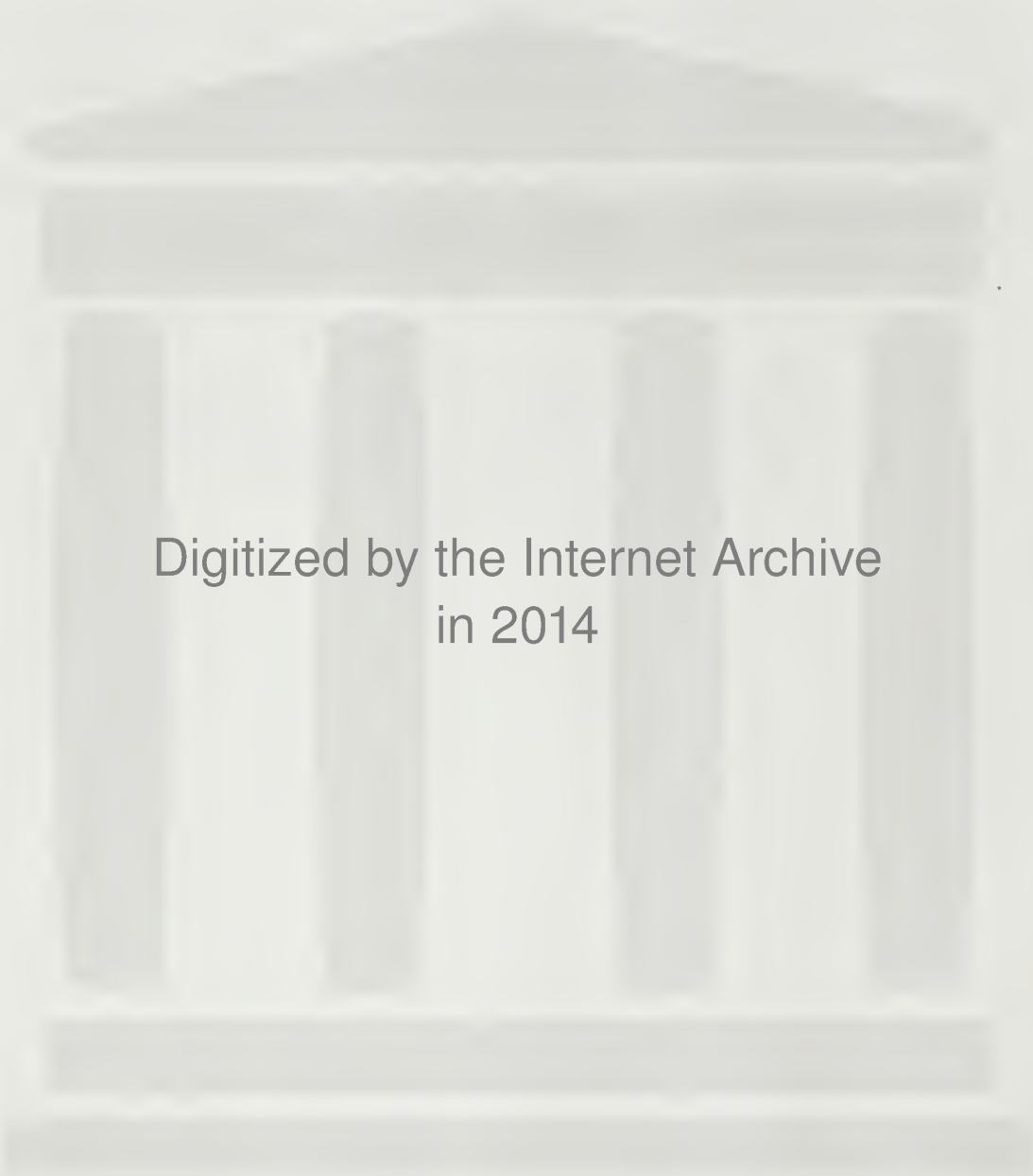
CA/T Project managers have been fully apprised of my concerns and accorded ample opportunity to review and comment on the report. The Project's formal written response is included at the end of the report. I am pleased to note that steps are already being taken to address the issues I have raised.

I would like to thank Neil Cohen, Deputy Chief of my Contract Audit and Review Division, for conducting this extensive review and writing this report.

Sincerely,

Robert A. Cerasoli

Robert A. Cerasoli
Inspector General



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Publication No. 17655-67-500-12/94 IGO, approved by Philmore Anderson III, State Purchasing Agent
Printed on Recycled Paper

EXECUTIVE SUMMARY

The $7.7 billion Central Artery/Tunnel (CA/T) Project involves constructing a new tunnel across Boston Harbor, placing the Central Artery underground, and constructing a new Charles River crossing. The Massachusetts Highway Department (MassHighway) is responsible for overseeing the Project for the Commonwealth. MassHighway has hired a management consultant, the joint venture of Bechtel Corporation and Parsons Brinckerhoff Quade and Douglas (B/PB) to manage the day-to-day operations of the CA/T Project. Since 1987, the estimated cost of the Project has increased from $2.5 billion to $7.7 billion. As the CA/T Project advances further into construction, costs will continue to increase unless MassHighway employs tough cost control measures.

Value engineering is a design review process aimed at simplifying designs and reducing design and construction costs. In 1987, MassHighway instructed B/PB to develop a value engineering program for the CA/T Project. The CA/T Project's value engineering program relied on teams of technical staff supervised by value engineering consultants under contract with B/PB.

The value engineering program generated 28 reports between August 1989 and April 1993 and recommended actions estimated to save a total of $2.8 billion. The total savings estimated by the value engineering teams is overstated since not every recommendation could be implemented. MassHighway accepted $325 million of the recommendations for implementation.

The Inspector General has concluded that MassHighway has not taken full advantage of value engineering, thereby forgoing opportunities to simplify designs and significantly cut costs.

The value engineering program is flawed not in concept, but in execution. Pursuing cost savings and design simplification has not been a high priority for the Project. From the beginning, the value engineering program has been plagued by a lack of independence, delays, misinformation, and management errors. As a result, the full potential of value engineering on the CA/T Project may never be known:

- Delays all but guaranteed that many cost-saving recommendations would be disregarded during final design because of the perceived impact on schedule and Project costs.

  Finding 1: Contrary to MassHighway's instructions and Federal Highway's advice, B/PB took two years to begin the value engineering program.

  Finding 2: The value engineering program stalled in 1990 after a late start in 1989.

Finding 3: Although value engineering resumed in 1991, delays had reduced the likelihood that value engineering recommendations would be implemented.

- A lack of management commitment to value engineering reduced program effectiveness.

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  Finding 7: Value engineering teams did not provide life-cycle cost-saving estimates for 99 percent of all value engineering recommendations.

  Finding 8: Value engineering teams provided construction cost-saving estimates for only 23 percent of all value engineering recommendations.

- There is no good reason for procuring value engineering services for the Project through B/PB.

  Finding 9: Employing staff from Bechtel Corporation and Parsons Brinckerhoff to perform value engineering analyses compromised the program's independence.

  Finding 10: MassHighway and B/PB failed to develop detailed guidelines for ensuring that B/PB implemented the value engineering recommendations MassHighway accepted.

  Finding 11: Contrary to its own guidelines, B/PB did not provide an adequate audit function for the value engineering program.

- The Project is continuing to forgo opportunities for cost cutting and design simplification during final design.

  Finding 12: The Project did not follow its plan to conduct studies during the final design stage.

In spite of the missteps, management errors, and poor planning, significant opportunities still exist for controlling costs through value engineering without delaying the CA/T Project. If MassHighway revitalizes the value engineering program, avoiding the pitfalls documented in this report, Project leadership could sharpen one of its key cost-control tools. The Inspector General recommends that MassHighway:

1. **Eliminate B/PB from its current pivotal role in managing the value engineering program.** Staff value engineering teams with independent professionals and hire an independent firm to lead these activities. Confine B/PB's role to commenting as the design originator on the value engineering recommendations and supporting the value engineering effort as MassHighway's Project manager.

2. **Conduct a comprehensive value engineering program review.** For all Project segments still under design, examine the value engineering recommendations that were earlier rejected or ignored. Consider conducting value engineering assessments during final design. Where feasible, implement cost cutting measures during design rather than waiting until construction when costs are higher and savings may be split with the contractor.

3. **Remold the value engineering program to ensure its independence and usefulness as a cost-control tool.** Schedule studies to permit timely team and departmental review. Provide value engineering teams and section design consultants with the timely and accurate information they need to propose changes and assess the cost-saving potential, including life-cycle cost estimates. Document the reasons for rejecting or accepting recommendations, and record directions for further study and implementation. Establish clear implementation guidelines and schedules. Hold B/PB accountable for implementation in a complete and timely manner each recommendation MassHighway accepts. Charge a strong and independent audit team with monitoring and verifying implementation. Expand the audit mission to scrutinizing the justification for rejecting value engineering recommendations.

At current funding levels, the Commonwealth's share of the $7.7 billion CA/T Project will cost taxpayers more than $1 billion. But that is only part of the cost. The Commonwealth will foot the entire bill for operating and maintaining the Project. In most cases, however, value engineering teams failed to estimate life-cycle costs -- that is, the full cost to construct, operate and maintain the CA/T facilities. Neither Federal Highway nor B/PB has any incentive to attend to these future costs; neither entity will pay the bills. This Office will continue to monitor and alert MassHighway to value engineering problems.

INTRODUCTION

The $7.7 billion Central Artery/Third Harbor Tunnel Project (the CA/T Project) involves constructing a new tunnel across Boston Harbor, placing the Central Artery underground, and constructing a new Charles River crossing. The federal government anticipates funding approximately 86 percent of CA/T Project costs.[a] The CA/T Project has a scheduled completion date of 2004.

The Massachusetts Highway Department (MassHighway) is responsible for overseeing the CA/T Project for the Commonwealth. MassHighway has hired a management consultant, the joint venture of Bechtel Corporation and Parsons Brinckerhoff Quade and Douglas (B/PB), to manage the day-to-day operations of the CA/T Project. Overseeing the CA/T Project for the federal government is the Federal Highway Administration (Federal Highway).

Since 1987, the estimated cost of the CA/T Project has increased from $2.5 billion to $7.7 billion. Much of this increase is attributable to changes in the scope of the CA/T Project, the redesign of major Project elements such as the Charles River crossing, and cost overruns.

As of August 1994, cost overruns on $1.5 billion worth of awarded CA/T contracts (both design and construction) totalled nearly 25 percent or $350 million,[b] although construction had barely begun. As the CA/T Project advances further into construction, which is a costly and complicated enterprise, construction contract costs will continue to increase unless MassHighway employs tough cost control measures.

According to Federal Highway, one measure with great cost control potential is value engineering, a method of altering designs without affecting their reliability or performance. MassHighway introduced its value engineering program for the CA/T

Project in 1989. According to MassHighway: "Never before has a VE [value engineering] program of this magnitude been implemented."

To date, the value engineering program has produced recommendations for Project design changes estimated to offer savings totalling more than $2.8 billion. As a practical matter, the $2.8 billion overstates the actual potential savings from value engineering: some recommendations may conflict with each other; some may obviate the need for others; and some may not, upon closer evaluation, be advisable. Clearly, however, value engineering offers substantial potential for savings.

MassHighway has accepted more than 300 of the 625 value engineering recommendations developed by the program. Some of these are relatively minor, and others included no estimates of potential savings. Overall, MassHighway estimates that it has saved $325 million by implementing the accepted recommendations. Most of these savings are reflected in the revised Project cost estimate and apply to contracts that have yet to be awarded.

In June 1992, the Inspector General for the U.S. Department of Transportation stated during Congressional testimony that most federally funded projects do not realize the maximum savings from value engineering programs.[c] The reasons cited by the Department of Transportation's Inspector General include:

- lack of support for the program
- failure to provide adequate resources for the program
- poorly defined program procedures
- failure to monitor the program and
- lack of interest in value engineering recommendations.

This Office's review has revealed that the CA/T Project's value engineering program encountered all of these problems in varying degrees. Although adequate in design, the program's implementation was inadequate. As a result, MassHighway has not taken full advantage of value engineering, thereby forgoing opportunities to simplify designs and significantly cut costs. MassHighway, however, may be able to capture additional savings by implementing some previously neglected value engineering recommendations.

THE VALUE ENGINEERING PROGRAM

Since the CA/T Project began, Federal Highway has strongly recommended value engineering because of its cost control potential. Federal Highway's *Value Engineering for Highways* (1983) describes value engineering as follows:

> Value Engineering is the most effective technique known to identify and eliminate unnecessary costs in product design, testing, manufacturing, construction, operations, maintenance, data, procedures and practices.

Value engineering examines designs in terms of their most basic functions. The value engineering process then attempts to join these basic functions with accepted standards for quality, reliability, safety, and aesthetics. The goal is to meet all requirements in the simplest way and at the lowest possible life-cycle cost. Life-cycle costs, a key component of value engineering, include costs for construction, operations, and maintenance. Knowing these costs is vital to properly assessing any design. According to Federal Highway, the earlier in design that value engineering is performed, the greater its cost reduction potential.

In August 1988, MassHighway's CA/T Project Director approved B/PB's proposal for a value engineering program.[d] In 1991, at the direction of MassHighway, B/PB prepared the value engineering program's guiding document, the *Value Engineering Program Manual* (program manual). According to the program manual, the value engineering program was to be conducted "consistent with Federal Highway Administration policy governing the application of value engineering on federally funded highway projects." The program manual offered this definition of value engineering:

> [Value engineering is] an organized, proven approach to identifying and reducing costs; and increasing value. Its objectives are no different from the everyday goal in professional and private lives, to get the maximum

> benefit out of every dollar spent. Its techniques . . . have been deliberately developed in ways that give a somewhat different view of a project from that of the [design] team . . . .

With MassHighway's approval, B/PB employed engineers from Bechtel Corporation and Parsons Brinckerhoff Quade and Douglas, who otherwise did not work on the CA/T Project, to review the work that B/PB had performed for the Project. Their task was to perform value engineering studies and participate in workshops. The workshops consisted of teams of three to 11 engineers and generally lasted from three to five days. To coordinate the teams' efforts and prepare study reports, B/PB (with MassHighway's approval) contracted with two value engineering subconsultants in 1989: Olympic Associates, Inc., and Smith Hinchman and Grylls, Inc.

In addition to team reports, B/PB's proposal called for another type of study, referred to as criteria reviews. For these studies, one engineer from Bechtel Corporation or Parsons Brinckerhoff Quade and Douglas with expertise in a specific field, such as electrical engineering, was given three days to comment on the Project-wide design standards for that field. For example, an electrical engineer might comment on circuit types, bulb wattage, and conduit types.

After a value engineering team or individual reviewer (for the criteria reviews) made recommendations to MassHighway, it was B/PB's responsibility to advise MassHighway on how each study recommendation should be handled. MassHighway made the final determination as to whether value engineering recommendations would be accepted or rejected.

Some examples of the recommendations offered by the value engineering program include:

- Construct a bridge instead of a tunnel across the Fort Point Channel - $145 million savings. (Rejected.)[1]

- Change the location of a toll plaza - $5 million savings. (Accepted but B/PB, disagreeing with the value engineering team, estimated that there would be no cost savings.)

- Eliminate overweight vehicle detectors - $200,000 savings. (Accepted.)

Value engineering is also used during construction through the value engineering change proposal. According to the American Association of State Highway and Transportation Officials (AASHTO),[2] "the program [change proposal] offers an opportunity to the contractors to demonstrate ingenuity and construction excellence and receive financial benefit." When a contractor identifies an opportunity to improve or maintain design quality at a lower cost, the contractor submits a proposal to MassHighway through B/PB. If accepted, half of the net savings from the change proposal are credited to the contractor.[3] The intent of this financial incentive is to encourage contractors to challenge excessive design.

The value engineering program has proven to be a valuable tool for reducing costs and improving designs and procedures. Indeed, MassHighway has saved a significant sum through the program, and Federal Highway points to the CA/T Project's value engineering program as a model for other projects. Nonetheless, it is clear that MassHighway has not taken full advantage of value engineering and its cost-saving potential.

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[1] The design for the Fort Point Channel crossing is currently being re-evaluated by the Project.

[2] The American Association of State Highway and Transportation Officials (AASHTO) is a respected source for construction standards. AASHTO guidelines are used extensively on the CA/T Project for design and construction standards.

[3] According to MassHighway's *General Requirements and Covenants of Construction Contracts* (Section 8.00, September 18, 1992), the net value engineering savings for a change proposal are calculated by subtracting total redesign costs from the total estimated savings. From this amount, B/PB calculates the contractor's incentive credit.

Finding 1: Contrary to MassHighway's instructions and Federal Highway's advice, B/PB took two years to begin the value engineering program.

According to Federal Highway's *Value Engineering for Highways*: "The earlier Value Engineering is performed, the greater is its savings potential." B/PB's April 1987 *Preliminary Project Management Plan*[4] states: "The [value engineering] process will be primarily performed early in the design stage so as to achieve the most cost effective designs." The value engineering program, however, did not begin until August 1989.

B/PB did not follow either its own plan or Federal Highway's advice to begin the value engineering program early. For example, B/PB conducted the first value engineering workshop on August 20, 1989 -- two years after MassHighway first directed B/PB to hire a value engineering subconsultant and one year after MassHighway approved B/PB's plans for a value engineering program.

As early as November 1987, Federal Highway expressed concern with the lack of value engineering progress:

> The working alignment and basic design concepts for various areas of the project are currently under review and are being presented at public meetings. **In order to avoid lost opportunities for potential value engineering alternates, it is imperative that the engagement of a value engineering firm be advanced expeditiously. We are unaware of significant progress . . . .** [Emphasis added]

[4] B/PB developed, and MassHighway approved, the *Preliminary Project Management Plan* to delineate the services B/PB promised to deliver under its contracts with MassHighway.

When questioned during a May 1994 interview about the delay, MassHighway's value engineering manager acknowledged that "we could have done things sooner." During that same interview, B/PB staff gave three reasons for not having done so: (1) they developed the value engineering program "from scratch"; (2) they had followed lengthy state procurement procedures to hire a value engineering subconsultant; and (3) they had been occupied with reviews of Project designs which were first available in late 1989, according to B/PB staff.

CA/T Project documents contradict these explanations. First, B/PB did not develop the value engineering program from scratch. According to both the B/PB staff and the *Value Engineering Program Manual*, B/PB used existing Federal Highway and AASHTO documents to develop the program. In fact, B/PB took the value engineering worksheets directly from Federal Highway documents. These worksheets, along with instructions, comprised about two-thirds of the first program manual. Project Procedure # 415,[5] issued in December 1990 after B/PB conducted eight value engineering studies, appears to be the only unique value engineering document produced by the Project.

Second, B/PB delayed procuring a subconsultant. This delay was not due to the state procurement process, as B/PB staff has stated. In September 1987, MassHighway directed B/PB to prepare a scope of services for a value engineering subconsultant "as soon as possible."[e] In May 1988, B/PB's CA/T Project Manager asked MassHighway to exempt the process from state requirements for competitive procurement. According to Project documents, B/PB made the request because value engineering had started late and "the usual [consultant] selection steps" would cause further delay.[f] MassHighway, however, did not approve any procedural changes. B/PB did not advertise for letters of interest, the first stage of the procurement process, until

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[5] Project Procedures are developed by B/PB and approved by MassHighway. These Procedures represent how Project staff should perform specific functions. B/PB is obligated to follow these procedures.

the following October -- five months after stating that the program was late. In June 1989, almost two years after MassHighway directed B/PB to do so, B/PB finally hired two subconsultants, through a competitive procurement process.

Third, notwithstanding B/PB's claim that its preliminary designers did not have designs available for review until late 1989,[6] Federal Highway stated in April 1989 that designs could be reviewed:

> We remain concerned with the progress of the Value Engineering (VE) Program for the CA/THT Project. . . . With most of the 100 scale[7] design packages now available for review it is unclear why VE studies cannot proceed in the near future. Furthermore, most of the concept reports and project design criteria are available in at least draft form and could be subjected to VE criteria reviews.[8]

Federal Highway was correct: B/PB had designs ready for review. In fact, B/PB advertised for and chose subconsultants and MassHighway awarded final design contracts before the first value engineering workshop in August 1989. Enough preliminary design work had been completed to permit value engineering well before August 1989.

For example, the value engineering study for the immersed tube sections of the third harbor tunnel was not conducted until September 1989. B/PB had provided the value engineering team with early design drawings completed months before. B/PB was at the same time in the process of awarding a final design contract for the immersed

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[6] The first value engineering workshop was conducted during August 1989.

[7] One hundred-scale designs represent approximately 15 percent of design completion. Forty-scale designs represent approximately 25 percent of design completion. After 40-scale designs are completed, MassHighway usually enters into a contract with a final designer or section design consultant to complete the design. B/PB oversees the design consultant's work on MassHighway's behalf.

tube sections and therefore had advanced design beyond the 100-scale drawings that the value engineering team was reviewing.

Finding 2: The value engineering program stalled in 1990 after a late start in 1989.

B/PB performs the preliminary design work and brings the design package to approximately 25 percent completion. Then, with MassHighway's approval, B/PB hires and oversees a final designer who is responsible for completing the design work. According to the *Value Engineering Program Manual*, preliminary design is the optimum stage for value engineering. (This is shown in Figure 1.)

Under the terms of the 1988 *Value Engineering Program Proposal* (B/PB's plan for a value engineering program), B/PB planned to conduct 22 value engineering studies by June 1990. B/PB had conducted only eight studies by that date: seven in 1989 and one in 1990. B/PB did not conduct the remaining 14 planned studies -- two-thirds of the total -- on schedule. By 1990, B/PB had advanced most of the CA/T Project's designs to either preliminary design or the beginning of final design.

Federal Highway remained concerned about the lack of progress. In a July 1990 letter to MassHighway, Federal Highway asserted that "further Federal-Aid participation in these activities cannot be assured unless these items are adequately addressed."[h] The B/PB value engineering manager wrote to all B/PB core managers in October 1990: "We want to initiate a push on VE [value engineering] work again. . . . [P]lease keep in mind that we have to play a little catch-up here."[i] Shortly thereafter, B/PB provided to MassHighway a list of more than 20 planned studies. In 1990, MassHighway also set up a value engineering reporting system and study schedule. CA/T Project documents do not explain why MassHighway authorized only one study to be performed in 1990. MassHighway's value engineering manager, in a May 1994

interview with this Office, stated: "There was a change in philosophy about how much we wanted to study." In December 1994, MassHighway explained in a letter that the value engineering program was inactive in 1990 because it "underwent a re-evaluation."

Figure 1: Net Savings Potential of Value Engineering Performed at Different Stages of Design, Construction, and Operation.

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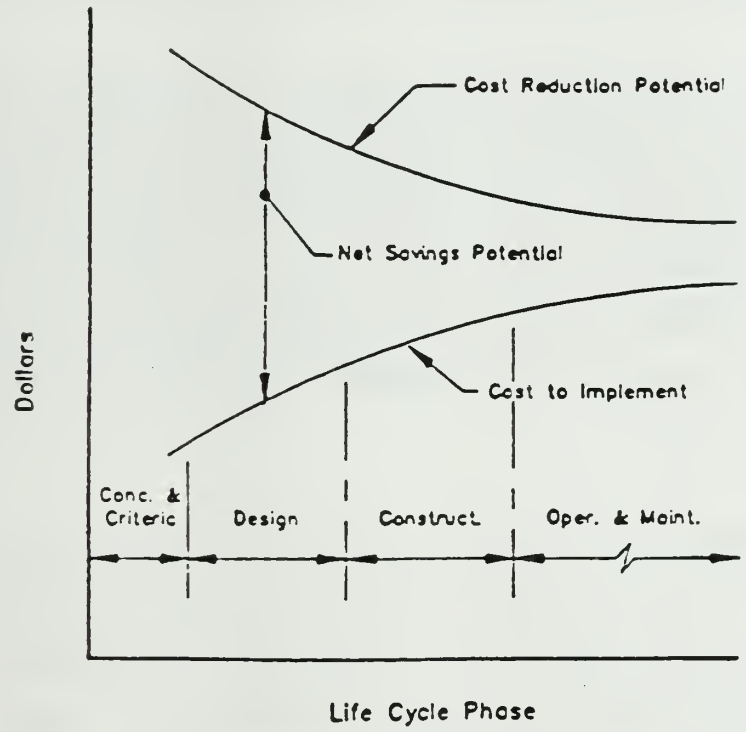

Fig. 4 Net Saving Potential

Source: CA/T Project's *Value Engineering Program Manual*

Finding 3: Although value engineering resumed in 1991, delays had reduced the likelihood that value engineering recommendations would be implemented.

AASHTO's *Guidelines for Value Engineering* warn: "If a study is scheduled too late[,] . . . opportunities for implementing the recommendations are usually lost due to tight schedules." Concerned about the possible conflict between value engineering and the Project's design schedule, Federal Highway advised MassHighway in a March 1991 letter: "We have some concern with the ability to undertake all of these studies within a time-frame which will provide maximum benefit."[i]

Federal Highway had reason to be concerned. Of the 16 studies conducted in 1991, 14 addressed Project-wide design criteria or programs. Yet during the same period, MassHighway had contracted for 15 major final designs including materials disposal, mechanical and electrical systems, utility relocations, and parts of the Central Artery -- the same design areas scheduled for value engineering. In effect, MassHighway authorized value engineering studies *after* B/PB completed preliminary design packages and concepts.

By not commencing value engineering studies until after establishing the design criteria, B/PB all but guaranteed that cost-saving recommendations would be disregarded during final design because of the perceived impact on schedule and Project costs. This problem is illustrated by MassHighway's rejection of cost-saving recommendations to simplify tunnel portal designs at the two ends of the third harbor tunnel.[8] MassHighway accepted an April 1991 value engineering recommendation

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[8] This case is discussed in greater detail in a letter issued by this Office to the CA/T Project Director on September 13, 1994. See Appendix A.

to simplify all mainline tunnel portals except those at the two ends of the third harbor tunnel because the Project schedule would not allow design changes.[k]

The 16 new value engineering studies conducted in 1991 offered 99 cost-saving recommendations with a total estimated savings potential of $1.5 billion. B/PB advised MassHighway to accept only five of the cost-saving recommendations, valued at $5.5 million.

After a flurry of activity in 1991, the value engineering program for the Project's design stage had stalled again.

B/PB has conducted four studies since 1991. To date, no other studies have been planned. B/PB has completed two of the four studies performed since 1991, and two others are still being reviewed; no cost-saving recommendations have been accepted from any of the four studies. In an interview with this Office, Federal Highway staff stated, that additional value engineering opportunities exist, but that MassHighway must take the initiative to authorize any additional studies.

Finding 4: Project documents do not demonstrate that MassHighway and B/PB gave value engineering recommendations "full and fair" consideration.

In many cases, B/PB advised MassHighway to reject value engineering recommendations with little or no documentation to support its position. Consequently, as MassHighway managers considered B/PB's advice, they did not in most cases have the benefit of such documented analysis as cost estimates, drawings, and technical information. Apparently, MassHighway had only B/PB's assurances that its recommendations to reject were justified. In most cases, MassHighway acted on B/PB's advice. AASHTO's *Guidelines for Value Engineering* states:

> It is important that all recommendations receive serious consideration. . . . Full and fair evaluation of all proposals and implementation of those determined to be viable is also a major part of the value engineering program.

In November 1989, MassHighway reproached B/PB for its inadequate evaluation of value engineering recommendations:

> In general, the responses to the East Boston recommendations were very flimsy and toothless. . . . I think most have to be beefed up, and if I were the Feds, I wouldn't approve them. . . . VE gives us a cost savings . . . but the response doesn't refute it or give costs of alternatives. How can we argue the case without costs? . . . [T]his is VE's strongest recommendation, yet the response brushes it off in a paragraph.[1] [Emphasis in original text.]

Nonetheless, this Office's review revealed that often B/PB continued to brush off value engineering recommendations.

For example, in November 1989, the *South Bay Interchange 100-Scale* value engineering study team recommended a bridge to replace a proposed tunnel to cross Fort Point Channel for a savings of $115 million. According to the team, a bridge could:

- create a $75 million construction cost reduction;
- create a $40 million life-cycle cost reduction[9] for the Commonwealth;[10]
- eliminate most of the risk involved with constructing a tunnel only a few feet away from the Massachusetts Bay Transportation Authority's Red Line subway tunnel that is also under the channel;
- reduce environmental concerns; and
- speed construction time by two years.[11]

B/PB advised MassHighway to reject this $115 million cost reduction opportunity. Early drafts of B/PB's evaluation of the value engineering recommendation stated: "This recommendation not only deviates from Project Policy but also deviates from Project Constraints."[m] B/PB's value engineering manager expressed dissatisfaction with B/PB's position:

> There seem to be too many references to "project policy." . . . The Design Team should focus on specific issues (not project policy) . . . . Where did the "project policy" thing come from? This is the only VE

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[9] Life-cycle costs include construction and design costs, operations and maintenance costs, energy costs, repair costs, and any other costs expected over a structure's lifetime. Value engineering studies on the CA/T Project usually reported construction and design cost-savings separately from other life-cycle costs.

[10] The value engineering team estimated a yearly operations and maintenance cost savings of $2 million. B/PB's *Value Engineering Annual Federal Aid Summary Report* projected a 20-year life-cycle. Savings of $2 million a year for 20 years would total $40 million, excluding interest and inflation factors.

[11] Problems have arisen recently with the Fort Point Channel tunnel as designed. As a result, MassHighway is reportedly considering alternative designs, including a bridge option.

> study where it is so prominent.[12] The Design Team response as presently configured is not likely to be acceptable to the FHWA [Federal Highway].[n] [Emphasis in original text.]

B/PB later revised its response, claiming that the use of another value engineering recommendation with a lower cost-savings potential from the same study precluded the use of the bridge alternative. Project documents provided to this Office contained no record of any analysis to support this claim.

In a January 1993 report, the U.S. Department of Transportation's Office of the Inspector General (DOT IG) offered its own explanation for the rejection of the value engineering recommendation:

> [T]he bridge alternative was never given serious consideration. . . . [T]he State had a preconceived disposition towards a tunnel and specifically against a bridge . . . [so] this VE recommendation was rejected as not being technically feasible.[o] [Emphasis added.]

The DOT IG's report recommended that Federal Highway "seek a higher share from the State for those recommended savings lost because of an arbitrary rejection by the State." If Federal Highway takes this advice, the Commonwealth could pay as much as $75 million more in construction costs for a tunnel. B/PB, at MassHighway's direction, is currently investigating design alternatives for the Fort Point Channel crossing.

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[12] At this point in the value engineering process, B/PB had only conducted five studies of the 28 it would eventually conduct. Project policy and commitments are mentioned again in later studies.

B/PB did not keep minutes of value engineering decision meetings.

According to the *Project Management Plan*: "All meetings, reviews, conferences, and **decisions of material significance to the project** will be documented in the form of meeting/conference notes or as a report and distributed. . . ." [Emphasis added in bold type.] Meeting minutes that record the decision-making process are key to holding decision-makers accountable for their actions and providing a basis for implementation. In the case of value engineering, B/PB staff advised key MassHighway staff about billions of dollars in potential cost reductions. Decisions about significant design and procedural issues were recorded, but the basis for these decisions -- and who made them -- was not.[13]

B/PB's value engineering manager stated in an interview with this Office that no minutes were kept of the meetings where MassHighway in consultation with B/PB decided to accept or reject value engineering recommendations. MassHighway's value engineering manager explained: "These were just informal gatherings with Project staff. We were all on the same team so we didn't bother [to keep minutes]."

At one "informal gathering," where staff recorded no minutes, MassHighway decided to reject an $8.7 million value engineering recommendation from the April 1991 *Architectural* study. The value engineering team had suggested using standard vehicle or jersey barriers instead of the "modified, more expensive version" of the barrier B/PB had designed to be fabricated on site. In its response to the value engineering team's recommendation, B/PB advised MassHighway to reject the recommendation, stating that the standard barriers would be "unsightly" and that its barrier design provided

[13] Federal Highway staff monitoring the CA/T Project also failed to document what transpired during meetings they attended, including those they initiated.

additional protection against "deterioration." B/PB provided neither additional information nor analysis of the options outlined by the value engineering team. In its response to the recommendation MassHighway concurred with B/PB and rejected the recommendation, explaining that the "shape and appearance" of the viaducts (where barriers are to be placed) had been an "architectural priority" for the Project in order to "mitigate negative visual impacts."

This Office does not question MassHighway's attention to visual impacts. This Office is concerned, however, by the Project's failure to examine the possibility of less costly alternatives to the barrier design to meet the Project's "architectural priority." For example, B/PB could have pursued the value engineering suggestion to use precast concrete for its barrier design. Instead, MassHighway rejected the idea without adequate documentation and, apparently, without adequate review.

In another inadequately documented value engineering decision, B/PB advised MassHighway, and MassHighway agreed, to reject an $83 million[14] recommendation from the June 1992 *South Bay Interchange-Kneeland to Randolph* study proposing the replacement of one steel viaduct type with another. B/PB explained:

> We concur with the VE teams cost-oriented observations. The VE team, in fact, used numbers from our own report so there can be no disputing of these costs. The project has a commitment, however, that is more far-reaching than costs alone. Our commitment includes due consideration for aesthetics and interface with current and projected community development. . . .

Project documents reviewed by this Office do not demonstrate which commitments and community development issues led to the rejection of $83 million in potential

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[14] Since the value engineering team's suggestion applied only to the South Bay design area (containing only three of the eight design contracts that will have bridges or viaducts), the Project-wide savings potential could be much higher. CA/T Project value engineering documents do not contain a B/PB Project-wide estimate.

cost-savings. This Office does not question whether aesthetics and community development are important Project considerations. What concerns this Office is the lack of meaningful documentation to explain how and why MassHighway, in the fourth year of the value engineering program, made this major decision.

Project documents do not show whether MassHighway's decision-making process included community input or whether the outcome fully addresses mitigation concerns. The absence of documentation suggests this was a subjective decision based on the speculation of Project architects and engineers rather than a cost-conscious response to community concerns. MassHighway managers informed this Office that other reasons existed for rejecting this recommendation; however, they have not been able to support their recollection of events with documentation or more than general statements about the event.

Meeting minutes ought to record the factors considered in the decision-making process as well as the decision itself. Without a clear record, the Project and ultimately the Commonwealth are dependent upon the recollections of individual staff. When staff depart, institutional memory is lost. The rationale for rejecting a recommendation may be valid at the time the decision is made, but it may change as the Project progresses. Clear and complete minutes and other records would allow management to revisit its decisions to reject value engineering recommendations in light of changed circumstances.

Finding 5: B/PB did not address value engineering recommendations in a timely manner.

As discussed earlier in this report, the likelihood that value engineering recommendations will be implemented decreases over time. Therefore, a timely review is critical to ensuring that the recommendations receive a full and fair evaluation. As early as January 1990, six months after B/PB conducted the first workshop study, Federal Highway criticized the lack of timeliness of CA/T Project responses to value engineering recommendations:

> [W]e are concerned with the apparent time lag between conduct of individual VE studies and the submission of final Study Reports. Timely responses by B/PB and the Department are of critical importance . . . .[p]

In June 1990, Federal Highway again expressed concern about a lack of timely decision-making:

> [C]onsistent and timely decision-making and implementation of VE recommendations is lacking. The subject VE study was conducted well over one year (August 28 - September 1, 1989) prior to the Department's attached letter of disposition (October 4, 1990). The lack of effective management of the VE Program and accompanying delay in providing reasonable assessment of several of the recommendations contained in the subject Study Report severely compromises the integrity of the VE Program as well as the project development activities for the CA/THT Project.[q] [Emphases in original text.]

The report issued by the DOT IG explained: "The State advised us that because of emphasis on completing the Project's preliminary design, the consultant [B/PB] considered review of VE [value engineering] studies to be of secondary importance."

Two examples illustrate how B/PB's inadequate and tardy review impacted the Program's effectiveness. First, the *Structural Design Criteria Review* issued in May

1989 and the *South Bay* study issued in November 1989, conducted at the 100-scale design stage, recommended less expensive and easier-to-construct alternatives to slurry walls.[15] B/PB responded to the May 1989 criteria review almost two years later, in March 1991. B/PB delayed for seven months before responding to the November 1989 *South Bay* study in June 1990. During these long delays, B/PB and its subconsultants developed slurry wall designs, which would later change in response to the value engineering recommendations. A more timely response to the suggestions could have saved the jobhours and money wasted on a slurry wall design that was later scrapped.

Second, MassHighway rejected a value engineering recommendation to simplify tunnel portals due to schedule constraints. (See Appendix A.) If a value engineering analysis had been done sooner, the recommendation would not have been rejected due to scheduling conflicts.

Finding 6: B/PB did not provide the value engineering teams with sufficient information.

The *Value Engineering Program Manual* describes the information value engineering teams need to complete their work, including complete graphic data (drawings, sketches, photographs); specifications and technical manuals; up-to-date cost estimates; and historical information. According to value engineering Project Procedure #415, developed by B/PB, B/PB is responsible for furnishing this information in advance of each value engineering study.

[15] Slurry walls are underground concrete walls used to support excavation as retaining walls. They may also be used for a structural foundation.

In at least three cases, B/PB did not provide the teams with sufficient cost data, as required by the program manual.

For example, in August 1991, the *South Bay I-93 Northbound* value engineering team noted the lack of up-to-date cost data:

> It became apparent that the current design and construction planning had advanced considerably beyond that represented in the most recent I.C.E. [Interstate Cost Estimate]. This disparity is certainly recognized by members of the project with whom the VE team had contact. . . . **It would facilitate the efforts of the VE team to have a current estimate available for use during the study period.** [Emphases added]

In another instance, the *South Boston Interchange 40-Scale* value engineering study team in March 1992 recommended that B/PB "[p]rovide more accurate and detailed estimate information and make an estimate expert available to the team to help interpret the information." In yet a third example, the *South Bay-40-Scale* value engineering study team commented in June 1992: "[A] review of the contract package C09C1 [cost] estimate reveals some omissions/errors." B/PB responded that the "inaccuracies" would be corrected prior to final design. CA/T Project documents contain no evidence of any such corrections.

In at least one case, B/PB's design teams changed preliminary designs but did not provide the most up-to-date designs to the value engineering teams.

The *South Boston 100-Scale* value engineering team recommended the elimination of a "Ramp E" for savings that B/PB estimated at more than $36 million. Unbeknownst to the team, B/PB had already eliminated this ramp before the study began. As a

result, the team wasted time by pursuing an issue that had already been settled by B/PB.

Finding 7: Value engineering teams did not provide life-cycle cost-saving estimates for 99 percent of all value engineering recommendations.

Life-cycle costs include estimates of construction and post-construction operations and maintenance costs. The *Value Engineering Program Manual* stresses the importance of cost estimates and urges the value engineering teams to "look beyond initial cost." The program manual explains: "[T]he costs of operation, maintenance, and disposal or replacement must always be taken into account. . . ."

Additionally, the standard value engineering worksheets used by both Federal Highway and B/PB instructed the value engineering teams to answer the following questions: "What will the alternative cost?" and "Has a cost estimate been made for each feasible idea?" Because operations and maintenance costs -- a key factor in life-cycle costs -- will be paid almost entirely by the Commonwealth, these costs should have been a significant factor in the teams' analyses.

Project Procedure #415 underscores the need for life-cycle cost estimates by stating that B/PB staff "will provide the VE Program Manager with suitable documentation to demonstrate the net estimated life cycle cost savings expected from each accepted proposal." But B/PB failed to ensure that the value engineering teams produced life-cycle cost estimates for their value engineering recommendations. In fact, both B/PB and MassHighway staff stated that they were unaware of any requirement to develop life-cycle costs.

The value engineering teams did not provide life-cycle cost-saving estimates for the vast majority of their recommendations. In fact, less than one percent (six out of

652) of all value engineering recommendations included life-cycle cost-saving estimates. An internal Federal Highway memorandum of December 1990 summed up the issue: "[L]ife cycle cost savings are not known. The absence of effective CA/THT VE Program management has made it extremely difficult to measure the success, if any, of the VE program."

Finding 8: Value engineering teams provided construction cost-saving estimates for only 23 percent of all value engineering recommendations.

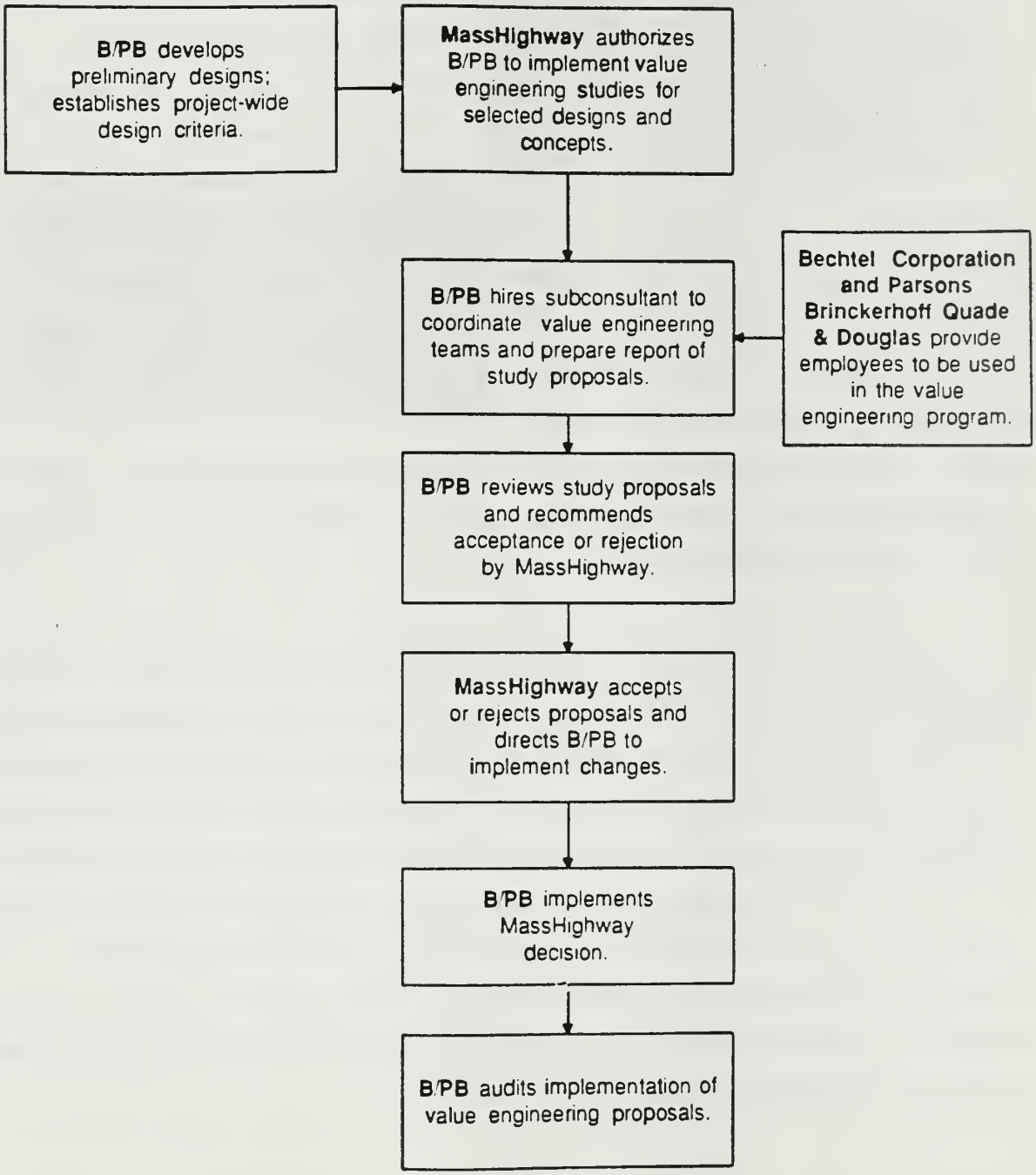
Only 152 of the total 652 value engineering recommendations contained specific cost-saving estimates. As with life-cycle cost savings, the teams should have provided this information for as many recommendations as possible. Not all recommendations involved cost savings, but it is reasonable to conclude that more than 23 percent impacted Project costs. This Office estimates that value engineering teams might have developed specific dollar savings for at least 100 additional recommendations. B/PB did not ensure that the teams provided this information, and MassHighway failed to require B/PB to provide it. Without this essential cost data, MassHighway could not make sound decisions on whether value engineering recommendations should be implemented. MassHighway stated in a letter to this Office that: "[the] issue [of the lack of cost estimates] was discussed at length." Project documents reviewed by this Office evidence no such discussion. Apparently, neither B/PB nor MassHighway documented these discussions.

Finding 9: Employing staff from Bechtel Corporation and Parsons Brinckerhoff to perform value engineering analyses compromised the program's independence.

As previously discussed, B/PB produced the preliminary designs and project-wide criteria that are subjected to value engineering review. B/PB then brought in employee teams from the joint venture companies (Bechtel Corporation and Parsons Brinckerhoff Quade and Douglas) to conduct the value engineering reviews under the guidance of a B/PB subconsultant. The value engineering team then submitted its recommendations to B/PB for review by the B/PB managers who performed the original work. B/PB subsequently advised MassHighway on whether to accept or reject the recommendations. (This process is shown in Figure 2.) The original subconsultant contracts were with B/PB, not MassHighway. If the Project wanted independence, MassHighway -- not B/PB -- should have contracted directly with the value engineering consultant.

The arrangement to use staff of the joint venture's parent companies has the potential to compromise independent review and comment. These employees may find it difficult to conduct critical reviews of the work of their colleagues involved in the Project. Corporate philosophy, corporate loyalty, job security, concern about future relationships, or the simple reluctance to criticize a colleague's work also factor into the value engineering team's assessments. The potential impact of these factors increases when B/PB employees change positions within their parent firms. In fact, one of B/PB's former deputy Project managers -- the number two person in the B/PB hierarchy -- had been a member of a value engineering team from Parsons Brinckerhoff Quade and Douglas prior to joining the Project.

Figure 2: Value Engineering on the Central Artery/Tunnel Project



Source: Prepared by the Massachusetts Office of the Inspector General

This risk to independence is unnecessary. A number of firms specialize in value engineering, including the two hired to oversee the B/PB employee teams. In contrast, Project documents reviewed by this Office show that Bechtel Corporation had to train employees in value engineering before undertaking this responsibility on the Project.[16]

Federal Highway approved the use of B/PB staff. When asked by this Office about the possibility that this arrangement undermined the independence of the value engineering reviews, Federal Highway staff said that they approved the use of B/PB staff because of the value engineering program's late start.

The late start does not justify the continued reliance upon B/PB for value engineering services. There is no good reason for continuing to procure value engineering services for the Project through B/PB.

MassHighway compounded the risk by not exercising close supervision over the program. Project documents reflect a very limited MassHighway role. MassHighway's value engineering manager stated in an interview with this Office that since he is also MassHighway's manager of structures, value engineering is not his primary responsibility. MassHighway does not have a full-time staff person assigned to the program, nor does B/PB. The Project has argued that B/PB's value engineering manager is independent because he reports directly to MassHighway on issues concerning value engineering. B/PB's manager, however, also has the title of Quality Assurance Manager. In his capacity as Quality Assurance Manager, the value engineering manager reports directly to B/PB management. In addition, MassHighway and B/PB each have only one other value engineering staff person who performs this role as needed on a part-time basis. Part-time responsibilities and multiple chains of command do not foster independence and clear lines of accountability.

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[16] Bechtel Corporation paid for value engineering training for those Bechtel employees chosen as possible value engineering team members.

The continuous use of the same value engineering firm could undermine its independence and objectivity.

During the pre-proposal meeting scheduled for interested subconsultant firms, B/PB's value engineering manager advised: "The work will be nearly equally divided between the two (2) successful proposers selected."

The Project subsequently contracted with Olympic Associates and Smith, Hinchman, and Grylls for value engineering services in 1989. Contrary to the original plan, the work was not "nearly equally divided between the two": Olympic Associates managed 20 of 22 value engineering workshops and has been the only firm used since June 1991.[17] The two studies that Smith Hinchman and Grylls managed accounted for 66 percent, or $214 million of the total $2.8 billion in estimated savings for all accepted value engineering recommendations.

Project documents provided to this Office do not explain why B/PB did not use Smith Hinchman and Grylls more often. Project staff has stated that Smith, Hinchman, and Grylls was not as available as Olympic Associates. No evidence was provided to this Office to support this contention.

The benefits derived from one consultant's familiarity with the CA/T Project (in this case Olympic Associates) must be weighed against the impact of the long-standing contractual relationship with B/PB, which has existed for over five years. Over time, the subconsultant's familiarity with CA/T Project policies, commitments, and

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[17] Olympic Associate's contractual obligation to the Project has changed. B/PB did not competitively reprocure these services after the original contract with Olympic expired in 1991. Olympic is now paid as a direct expense to B/PB under an open-ended contract.

standards could detract from the subconsultant's capacity to develop fresh design approaches and solutions.

Finding 10: MassHighway and B/PB failed to develop detailed guidelines for ensuring that B/PB implemented the value engineering recommendations MassHighway accepted.

According to Federal Highway's *Value Engineering for Highways*: "A poorly implemented proposal reflects discredit on all concerned." And Federal Highway warned: "Without implementation of reasonable VE recommendations, the benefits anticipated from the VE Program cannot be realized."[r]

For the CA/T Project, only the *Value Engineering Program Manual* and Project Procedure #415 discuss the implementation of value engineering recommendations. The program manual discusses implementation generally:

> Nothing can be taken for granted, even after the VE change proposals have been endorsed, until and unless the recommendations have been converted into actions. Hence, the VE **program manager** must maintain an active pursuit until the proposal is incorporated into the design as intended. . . . **An approved VE proposal should not be permitted to evaporate due to delays or inaction in the implementation process.** [Emphases added.]

Project Procedure #415 is only slightly more specific. It states: "[The] Design Manager affects implementation . . . by directing Area Design Managers to make appropriate changes to design documents. . . ." The rest of the procedure is vague. The program manual refers to the "program manager" as the responsible party, whereas the project procedure refers to the "design manager." It is unclear who is accountable for implementing the recommendations accepted by MassHighway.

In a letter written in May 1988, more than one year before B/PB conducted the first workshop, Federal Highway expressed concerns about the lack of implementation guidelines:

> It is not clear how the recommendations stemming from the criteria reviews, task team studies, and 40-hour workshops will be communicated to management and how management's decisions will be documented and communicated to the appropriate offices for implementation.

Federal Highway continued to express concern. For example:

- An internal Federal Highway memorandum from February 1989 stated: "One area that has not been addressed in the [program] manual is the implementation plan for VE recommendations."

- In a March 1989 letter, Federal Highway advised MassHighway: "There is no mention of the specific mechanics [in the program manual] by which the . . . Value Engineering proposals are to be accepted and implemented into the final designs and construction contracts."

- And again in a July 1990 letter, Federal Highway asserted: "It would appear that the current process for implementing VE recommendations is not working properly. A reevaluation of the current project procedures for VE may be warranted."

B/PB never developed specific guidelines defining the criteria, timing, or documentation requirements for implementation. MassHighway never took steps to ensure that B/PB did its job.

Finding 11: Contrary to its own guidelines, B/PB did not provide an adequate audit function for the value engineering program.

Both the *Value Engineering Program Manual* and value engineering procedures state that B/PB must conduct a closeout audit for each study. The closeout audit communicates the status of MassHighway-approved value engineering recommendations to B/PB's value engineering staff. Completing the closeout audits took B/PB staff a median time of 10 months, and up to 20 months in some cases. The program manual states: "The objective of the Audit Phase is to verify that the desired results have been achieved and properly documented. . . . The audit process is essential to the continuing success of the . . . VE program." B/PB's value engineering staff documented the audit results on a standard form, the Value *Engineering Closeout Audit*. The actual audit simply verifies that B/PB staff has acted to implement accepted value engineering recommendations.

As of March 1994, B/PB had completed only 14 closeout audits for 27 value engineering studies. These 14 audits were untimely and incomplete.

Moreover, the program manual directs the auditor(s) to recommend corrective action for the next project, initiate recommendations for additional value engineering studies, and most importantly, determine the effects on maintenance and other life-cycle costs. B/PB's closeout audits did not provide any of this information. As noted previously in this report, B/PB failed to develop life-cycle costs or to recommend additional value engineering studies. In those cases in which MassHighway had rejected a recommendation but directed further study by B/PB, MassHighway failed to ensure that the required study had been conducted. MassHighway managers informed this Office that B/PB conducted the audits to their satisfaction.

Finding 12: The Project did not follow its plan to conduct studies during the final design stage.

B/PB's *Value Engineering Program Proposal,* which MassHighway adopted in 1988, proposed conducting two studies for each major design area: one during preliminary design (about 20 percent of design) and one during final design (about 70 percent of design). B/PB failed to conduct studies beyond preliminary design. Project records contain no documentation of any decision by either B/PB or MassHighway to eliminate the planned final design studies.

According to February 1989 meeting minutes, MassHighway staff stated that they intended the value engineering program "to continue . . . through the final design process (by Section Design Consultants) right through construction." In February 1991, when the commitment to studies at the 70 percent design stage seemed to have been forgotten, Federal Highway and the value engineering subconsultant both suggested that MassHighway take "a closer look at each Section Design" because "it might make sense to select a 75% [design] submittal and see what the outcome is." Project documents provided to this Office show no evidence that B/PB conducted a study at the 75 percent design stage.

At least seven value engineering teams told MassHighway that additional design reviews would benefit the CA/T Project. For example, in August 1991 the *South Bay* value engineering team members advocated for final design studies: "More VE studies at the 65% design stage should be performed on smaller items within this project . . . an average savings of 15% could be realized on each [study]. . . ." The *South Bay Interchange - 40-Scale* value engineering team stated in March 1992: "The VE team also recommends having VE studies of all or a portion of the Section Design packages. . . . Conducting the VE study after the new/fresh look of the Section Designers at a more detailed level should optimize the return (value improvement) to the project."

In an interview with this Office, however, B/PB's value engineering manager stated: "We don't apply VE to final design because we expect the SDC [section design consultant] to produce the optimum design; that's what they're being paid to do." This shortsighted philosophy does not bode well for the future of the value engineering program.

The consequences of B/PB not conducting value engineering studies at the final design stage are illustrated by the following example. In July 1991, B/PB issued the *Drainage and Utilities* value engineering study, which covered a number of designs in the final design stage. The value engineering team recommended the use of prefabricated rather than cast-in-place concrete sewer sections for the Porter Street Outfall relocation in East Boston, a design that was nearly complete at the time of the study. MassHighway, however, awarded the construction contract in November 1991 before B/PB had reviewed the value engineering team's recommendation submitted five months earlier.

Immediately after the award of the construction contract, the construction contractor used the value engineering change proposal process to propose using prefabricated rather than cast-in-place concrete sewer sections. MassHighway accepted the contractor's proposal and paid the contractor, in accordance with the terms of the change proposal, half of the almost $1 million in net savings. This expenditure would not have been necessary if MassHighway had reviewed and accepted the value engineering team's recommendation in a timely manner.

Because of B/PB's shortsightedness, the Project is continuing to forgo opportunities for cost cutting and design simplification during final design. Currently, there are a number of final designs that might benefit from a value engineering review. The Fort Point Channel crossing is being redesigned. In addition, the Charles River crossing design -- which replaced Scheme Z -- is in final design. The total estimated cost for the Charles River crossing alone is more than $1.6 billion.

Approximately 15 final design contracts have yet to be awarded. Each presents an opportunity to control costs through value engineering techniques, yet MassHighway has no plans to conduct value engineering studies for these contracts.

CONCLUSION AND RECOMMENDATIONS

The CA/T Project's value engineering program is flawed not in concept, but in execution. B/PB designed an adequate program. Indeed, Federal Highway encourages highway agencies in other states to model their value engineering programs on the one the CA/T Project adopted. As the preceding findings have shown, pursuing cost-saving opportunities through value engineering has not been a high priority for the CA/T Project. Both Federal Highway and the U.S. Department of Transportation Inspector General have warned repeatedly that delays and lack of management commitment to value engineering would undercut the program. But the CA/T Project failed to heed the warnings. From the beginning the value engineering program has been plagued by a lack of independence, delays, misinformation, and management errors. Neither MassHighway nor B/PB has made a serious effort to implement the value engineering program.

At current funding levels, the Commonwealth's share of the $7.7 billion CA/T Project will cost taxpayers more than $1 billion. But that is only part of the cost. The Commonwealth will foot the entire bill for operating and maintaining the Project. In most cases, however, value engineering teams failed to estimate life-cycle costs -- that is, the full cost to construct, operate and maintain the CA/T facilities. Neither Federal Highway nor B/PB has any incentive to attend to these future costs: neither will pay the bills.

In spite of the missteps, inadequate management, and poor planning documented in this report, significant opportunities still exist for controlling costs through value engineering without delaying the CA/T Project. Project design is only about two-thirds completed, and construction has only just begun. By revitalizing the value engineering program -- and avoiding the pitfalls documented in this report -- Project leadership could sharpen one of its key cost-control tools.

The Inspector General recommends that MassHighway take the following steps:

1. **Eliminate B/PB from its current pivotal role in managing the value engineering program.** Staff value engineering teams with independent professionals and hire an independent firm to lead these activities. Confine B/PB's role to commenting as the design originator on the value engineering recommendations and supporting the value engineering effort as MassHighway's Project manager.

2. **Conduct a comprehensive value engineering program review.** For all Project segments still under design, examine the value engineering recommendations that were earlier rejected or ignored. Consider conducting value engineering assessments during final design. Where feasible, implement cost-control measures during design, rather than waiting until construction when costs are higher and savings may be split with the contractor.

3. **Remold the value engineering program to ensure its independence and usefulness as a cost-control tool.** Consider the following actions:

   - Schedule studies to permit timely team and departmental review.

   - Provide value engineering teams and section design consultants with the timely and accurate information they need to propose changes and assess the cost-saving potential, including life-cycle cost estimates.

   - Document the reasons for rejecting or accepting recommendations, and record directions for further study and implementation.

   - Establish clear implementation guidelines and schedules. Hold B/PB accountable for implementing in a complete and timely manner each recommendation MassHighway accepts.

   - Charge a strong and independent audit team with monitoring and verifying implementation. Expand the audit mission to scrutinizing the justification for rejecting value engineering recommendations.

ENDNOTES

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d. Twomey, William, Project Director, to M. Mirsky, B/PB Project Manager, letter, *Value Engineering,* January 29, 1988.

e. Tocci, Mario, Project Director, to M. Mirsky, B/PB Project Manager, letter, *Central Artery/Third Harbor Tunnel Project Proposed Three (3) Year Contract - Value Engineering*, September 21, 1987.

f. Mirsky, Melvin, B/PB Program Manager, to W. Twomey, Project Director, letter, *Proposal for Value Engineering Services*, May 20, 1988.

g. Almeida, Alex, Federal Highway Administration, to W. Twomey, Project Director, letter, *CA/THT - Value Engineering Program Status*, April 10, 1989.

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i. Delle, Aivars, B/PB, to Core Managers, memorandum, *Value Engineering Proposed VE Studies*, October 26, 1990.

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k. MassHighway to B/PB, Form 15 - Value Engineering Response, *Architecture - Value Engineering Report*, April 1991.

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m. Vears, James, B/PB, to C.E. Carlson, B/PB, memorandum, *Draft Implementation Plan*, November 28, 1989.

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p. Almeida, Alex, Federal Highway Administration, to W. Twomey, Project Director, letter, *Value Engineering Program Status,* January 19, 1990.

q. Doyle, Greg, Federal Highway Administration, to A. Almeida, Federal Highway Administration, memorandum, *Value Engineering - East Boston/Third Harbor Tunnel 100-Scale Study*, December 19, 1990.

r. Almeida, Alex, Federal Highway Administration, to W. Twomey, Project Director, letter, *Value Engineering Program Status*, January 19, 1990.

APPENDIX A: September 13, 1994 Tunnel Portal Letter from the Office of the Inspector General to the CA/T Project

The Commonwealth of Massachusetts
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September 13, 1994

Peter M. Zuk, Director
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Dear Mr. Zuk:

As you know, this Office has been reviewing the Department's Value Engineering (VE) Program for the Central Artery/Tunnel (CA/T) Project. As of June 1994, the Department's value engineering reviewers had conducted 28 VE studies and produced 625 design recommendations, 152 of which were accompanied by specific cost saving estimates. The VE reviewers estimated the total potential savings for the 152 VE recommendations to be $2.8 billion. The Department has rejected 136 of these recommendations, along with the estimated cost savings of $2.5 billion.

This letter examines the Department's response to one specific VE recommendation involving the simplification of the Project's standard tunnel portal design. In this case, the Department's poor planning, erratic decision-making, and overreliance on Bechtel/Parsons Brinckerhoff Quade and Douglas (B/PB) to manage the cost-reduction process may have cost the taxpayers as much as $13 million. Our ongoing VE review strongly suggests that the case described here is not an isolated incident.

In its architectural design concept report, B/PB describes tunnel portals, which are the exits and entrances to all the Project's tunnel sections, as "special events along the highway, functioning like major entrances to buildings." There are two portal types, the mainline portal and the ramp portal. The VE study and B/PB architectural design reports refer only to the seven mainline portals which are larger and more complex than the ramp portals. In October 1991, B/PB estimated the construction costs for the seven mainline tunnel portals to be almost $14 million.

In the April 1991 VE study entitled *Architecture*, the VE reviewers recommended simplifying the designs of these mainline portals, estimating that $13 million could be saved in construction costs alone. The VE reviewers suggested using "simple portal design in all instances instead of complex tiered or telescope designs" to lower costs. No specific life cycle cost savings for the operations and maintenance of the portals or landscaping costs were discussed in documents we reviewed. The one major downside, according to the reviewers, was that the more economical portals might be "less attractive."

Table # 1: Value Engineering Analysis of Tunnel Portals

April 1991 Value Engineering Report

- Total Construction Cost = $14 million
- Total Possible Savings = $13 million
- Total Revised Cost = $ 1 million

B/PB, although agreeing that savings could be achieved, dismissed the savings opportunity, stating "the [proposal] does not fulfill the design objectives but does indicate possible savings[.]"

The Department, however, directed B/PB to pursue cost savings with two exceptions: "reduction in mainline portals should be pursued for cost savings, except for those in [contracts] D004A and D007A [the contracts which contain the portals located at either end of the third harbor tunnel] which are constrained by schedule." We found no evidence that B/PB pursued any cost reductions or design changes in response to the Department's directive.

Two months after the April 1991 VE study, B/PB compared four portal design options in a report entitled *Comparative Cost Evaluation - Architectural Elements*. Although B/PB issued the report after the VE study, the VE-recommended portal design for $1 million was not included as an option. Rather, the report presented options with costs ranging from $10 million to $14 million. B/PB recommended that the Department keep the existing design. This was the most expensive option.

Project documents do not indicate any Department opposition to B/PB's choice of options. The Department approved major design packages that included B/PB's suggested portal designs. According to Project staff, the Department did not follow through on its earlier instruction to B/PB to pursue the VE recommendation, nor did the Department take serious measures to investigate lower cost design options. B/PB did nothing to respond to the Department's acceptance of the VE recommendation and the Department's instructions to investigate the recommended design change.

Project documents indicate that the Federal Highway Administration (FHWA) on more than one occasion during the design phase warned the Department that portal designs were too elaborate. In December 1991, eight months after the VE study, FHWA notified the Department that federal reimbursement for the portals would be only 75 percent of the cost instead of 90 percent due to the elaborate design:

> The elaborate design of the portals [has] been discussed on numerous occasion[s]. We believe . . . that 75% of the estimated cost can be used as a basis for Federal-aid participation.

According to FHWA staff, they had never before reduced federal funding to the Project for a specific design item. In this case, the elaborate design forced their hand.

In April 1992, a full year after the VE study, Project documents show that the Department approved changes simplifying the portal designs in response to separate requests from the Artery Business Council (ABC) and Massport. According to B/PB staff, ABC thought the original portal design was not aesthetically pleasing and Massport believed that the design would interfere with the functioning of certain airport taxiways.

Ironically, the portals that the ABC and Massport were concerned about were the very portals that the Department excluded from consideration after the VE report. Outside pressure from the ABC and Massport, not VE cost control, sparked the Project's design changes.

Notwithstanding the concerns of the ABC and Massport, the Department had three compelling reasons for simplifying the portal design in April 1991, more than a year earlier:

- The VE reviewers estimated that simplification of portal designs could save as much as $13 million.
- The FHWA was concerned that the existing design was too elaborate.
- The existing design was impractical in at least one location -- Logan Airport.

If the Department had seen to it that B/PB made the design changes earlier, $13 million could have been saved, if the VE team's estimates were correct. According to B/PB, the ABC- and Massport-initiated design changes will only save an estimated $850,000.

The taxpayers may have lost the difference between these two estimates, almost $12 million. When the portal design changes were finally made, many factors reduced the potential

for savings. Designs were well underway so any changes meant significant redesign costs and possible schedule delays. If the construction contracts had already been awarded, redesign costs might be greater still. The earlier redesign is done, the less expensive and time consuming a change will be. In this case, design changes were made very late in the process. Having VE reviews during preliminary design ensures that savings opportunities are not diminished by redesign costs.

Our ongoing review of the Department's VE process indicates that the Department's failure to follow up on cost savings in this instance is not an isolated case. In order to prevent the loss of other potential savings, the Department should require B/PB to provide detailed substantiation for its opposition to cost saving recommendations. The burden should be on B/PB to demonstrate why a VE proposal or other less expensive alternatives (which meet Project commitments for safety, aesthetics, etc.) are unacceptable to the Project. If no credible evidence is provided, then the VE proposal should be accepted. The Department must monitor B/PB's compliance with instructions and ensure that adequate guidelines exist for implementing VE proposals.

We will continue to apprise you of the results of our review. Please do not hesitate to contact me or Neil Cohen, Deputy, Contract Audit and Review Division, if you have any questions regarding these concerns.

Sincerely,

Wendy Haynes
Deputy Inspector General for
Contract Audit and Review

WH:NC

cc: William Flynn, Deputy Project Director
Susan Cobb, Counsel

APPENDIX B: Response to the Draft Report

On October 14, 1994, the Inspector General provided to MassHighway management a preliminary draft of this report. This Office fully considered MassHighway's subsequent written and oral comments, and modified the report where appropriate. The Inspector General then sent a final draft of the report to the Secretary of Transportation and the Project Director and requested a formal written response. The Project Director's letter, the Project's response to specific findings, and a list of documents transmitted with the response are included in this Appendix.

MassHighway generally agrees with the findings and recommendations in this report, but takes issue with certain statements and conclusions. This Office carefully examined all points of apparent dispute. In some cases, the Inspector General disagrees; the report speaks for itself and no further comment is needed. Several points, however, do merit specific comment:

Project's response to Finding #1: This Office's records show that B/PB staff, not MassHighway staff, provided the initial explanation for delays in implementing the value engineering program. During the interview, MassHighway staff concurred with and in certain cases elaborated on B/PB staff statements.

MassHighway continues to misinterpret this finding. The report documents and criticizes a two year delay from 1987 to 1989. The Project's response addresses the period 1989-1990 and thus misses the point of the finding.

Project's response to Finding #2: The Project's written explanation for the lack of value engineering workshops has been incorporated in the report; however, the three documents the Project attached to its response do not address the issues in this finding.

Project's response to Finding #3: Nothing in the Project's response causes the Inspector General to modify his findings and conclusions; the report speaks for itself. This Office is troubled, however, by the example the Project cites in which staff could only verify a $57,000 savings for value engineering recommendations originally estimated to save $907,000,000. A disparity of this magnitude -- a ratio of about 16,000 to 1 from estimate to verification -- is disturbing. This Office will pursue the matter.

Project's response to Finding #4: The Project should have kept meeting minutes; it did not. Decisions to reject or accept value engineering recommendations may well have been based on a careful weighing of "potential savings . . . with other important costs and impacts"; however, Project documents do not demonstrate that such a process occurred.

With respect to the choice of girders -- and the rejection of the $83 million cost saving potential -- the Project's explanation is incorrect. In fact, the value engineering team, in its work product, had already addressed the corrosion risk by recommending a "partially

painted steel plate girder" that was not as susceptible to corrosion. Moreover, Project documents show that only a small portion of the CA/T Project is on a "curved highway alignment"; therefore, the "superior structural support" provided by the more costly box girders is not necessary in most instances.

Project's response to Finding #9: Figure 2 has been modified to clarify the roles of MassHighway and B/PB.

Massachusetts Highway Department
Central Artery/Tunnel

December 7, 1994

Ms. Wendy Haynes
Deputy Inspector General
for Contract Audit and Review
Office of Inspector General
One Ashburton Place
Boston, MA 02108

Dear Ms. Haynes:

Thank you for the opportunity to review and comment on your office's report on the Central Artery/Tunnel Project's Value Engineering Program. Attached is our response that was prepared to indicate areas of agreement, correct errors, and clarify the record.

We view the report as a constructive document that will help the Project to improve its Value Engineering Program. The Central Artery/Tunnel Project's Value Engineering Program is a key element of the Massachusetts Highway Department's efforts to manage the Project efficiently and control costs. While we acknowledge that certain opportunities exist for improvement, we are very proud of our efforts on the VE Program. Never before has a VE program of this magnitude been implemented, and we believe that the program has generated substantial savings.

We appreciate the work your office has dedicated to this review and look forward to working with you on other Project related matters.

Sincerely,

For Peter M. Zuk
Project Director

AD-2.4.2
094-3915

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CENTRAL ARTERY/TUNNEL PROJECT
RESPONSE TO MASSACHUSETTS INSPECTOR GENERAL
REPORT ON VALUE ENGINEERING PROGRAM
December 6, 1994

INTRODUCTION

The Central Artery/Tunnel Project's Value Engineering Program is a key element of the Massachusetts Highway Department effort to manage the project efficiently and control costs. Of the 625 recommendations generated so far by VE engineering teams, more than 300 have been implemented, resulting in savings of more than $320 million.

We accept the general findings of the Inspector General's report, as the comments presented will help the project in continuing to improve the VE Program and reduce costs. However, there are several areas of disagreement which are important to note. In particular, we do not agree with the statement: "Although adequate in design, the program's implementation has been inadequate." (p.2) Never before has a VE program of this magnitude been implemented, nor have such extensive reporting and execution procedures been assembled. While we acknowledge that certain opportunities exist for improvement, the overall characterization of the CA/T Project's VE Program implementation as "inadequate" is not fair or consistent with the facts.

The report quotes extensively from documents generated during the early stages of the VE program from 1988 to 1990 but fails to note that in late 1990, MHD took aggressive action to resolve issues of concern, including:

- Assignment of VE responsibility to additional MHD support staff.
- Assignment of VE responsibility to B/PB on-site project personnel.
- Finalization of MHD approval of and FHWA concurrence with the VE program manual.
- Establishment of a VE reporting system.
- Establishment of an MHD- and FHWA-approved VE schedule and budget.
- Performance of the VE workshops according to schedule and budget.

We acknowledge that the timeliness of decisions regarding the implementation of accepted VE recommendations could have been improved. But regardless of any slow starts, the Central Artery/Tunnel Project has not missed a single opportunity to implement accepted VE recommendations. In fact, as the report notes, VE Program recommendations have generated substantial savings.

GENERAL ISSUES

We have two general areas of concern regarding the report:

1. Potential Savings

The VE Program has generated results that are typical of other U.S. Department of Transportation and FHWA projects. Therefore, we disagree with the statement that MHD has not taken full advantage of the VE Program and its cost savings potential. The project performed five VE studies in 1989, before final design had begun. The project subsequently performed 23 additional studies — a level of VE review that to our knowledge is unprecedented on USDOT and FHWA projects. These studies generated a total of 625 recommendations, 300 of which have been accepted.

According to U.S. Department of Transportation and FHWA's Value Engineering for Highways Guidelines (1983), "The designer/user usually accepts about half of these recommendations, providing a savings of at least five percent." (page xv) The implementation and close out of accepted recommendations has so far generated cost reductions of approximately $320 million, which is 6.6 percent of the CA/T Project's current $4.8 billion construction program budget. As more accepted recommendations are implemented, additional savings will be realized.

2. Procedure Definition and Monitoring

It is not accurate to state that the VE Program's procedures were "poorly defined" or that managers failed to monitor the program. Procedures were developed and modeled on existing and successful VE guidelines from FHWA. Detailed process procedures and flow charts were prepared, reviewed and included in the project procedures manual. Monitoring was accomplished through monthly reports transmitted to MHD and FHWA. These reports, which are highly detailed, provide updates on the status of all ongoing VE actions, as well as close out, audit, and implementation information.

FINDINGS

Following are responses to each of the findings in the report:

FINDING 1: "Contrary to Mass Highway's instructions and the Federal Highway's advice, B/PB took two years to begin the Value Engineering Program."

B/PB staff did not give 3 reasons for not having implemented VE sooner as stated in the report, rather it was Mass Highway's staff who, during the interview, provided the 3 reasons for not doing things sooner.

During the two-year period (1989-1990), numerous issues were being addressed to get the VE Program started. Most significantly, project staff were writing, reviewing, and obtaining MHD

and FHWA approval of the VE Program manual. Other issues addressed during this two-year period included:

- Establishing the schedule for VE workshops and studies.
- Procuring the services of VE subconsultants.
- Performing 100-scale (preliminary design) workshops.
- Training MHD, FHWA and B/PB personnel on the VE process.

The argument that this two-year period created a delay that reduced the overall effectiveness of the VE Program is flawed. Subsequent VE workshops and reviews were conducted during preliminary design, which is the design stage at which VE recommendations prove to be most cost effective. However, preliminary design cannot stop during VE reviews, which explains the report's concern for "timeliness."

The effort invested in developing a sound VE program creates benefits beyond the CA/T Project, since the VE procedures may be employed on future statewide highway projects.

FINDING 2: "The Value Engineering Program inexplicably stalled in 1990, after a late start in 1989."

The VE Program underwent a re-evaluation in 1990, as could be expected during the development of a major new initiative. The draft report's interpretation of a reduction in VE studies and workshops during this period as "stalled" is incorrect. MHD, FHWA, and B/PB managers were reviewing and evaluating the program's direction regarding topics, numbers of studies, and schedule. These issues were resolved and resulted in a new schedule being approved by Mass Highway and Federal Highway. This schedule is contained in Revision 0 of the Value Engineering Program Manual.

Project documents clearly indicate Mass Highway set up the value engineering reporting system and study schedule in response to Federal Highways concerns. Please refer to the 3 letters attached to this response.

FINDING 3: "Although Value Engineering resumed in 1991, delays had reduced the likelihood that value engineering recommendations would be implemented."

This statement is not consistent with the fact that despite some delays in deciding whether or not to implement accepted VE recommendations, the project has not missed any opportunities to actually implement VE recommendations. In 1991, it is true that Mass Highway authorized studies after B/PB completed preliminary design packages and concepts. The Value Engineering Workshops for B/PB completed concepts were performed in 1989 and 1990.

This finding also fails to reflect a key point which was stressed in interviews with Inspector General staff: many VE savings estimates are by necessity preliminary and should not be viewed

as precise savings. The report itself acknowledges this point on page 2: "As a practical matter, the (total estimated) $2.8 billion overstates the actual potential savings from value engineering." MHD, FHWA and B/PB concurred that VE savings estimates were preliminary and would not be used to determine actual dollar savings. The subsequent and more complex task of developing full savings estimates was left to project estimators.

VE savings estimates alone can be misleading. Comparing estimated VE savings with those that can actually be verified shows a wide gap between preliminary VE estimates and actual savings. For example, 23 of the VE recommendations accepted by the project from studies conducted in 1991 represented $907 million in potential "savings," according to the VE teams' estimates. However, the project could not verify the teams' estimates or document evidence of savings, and so only $57,000 in savings was actually claimed.

The report implies that the VE Program has stalled. This is also incorrect. The design phase of the VE program is concluding, and the VE Program's focus is now shifting to construction contractor proposals.

FINDING 4: "Project documents do not demonstrate that Mass Highway and B/PB gave value engineering recommendations 'full and fair' consideration."

We strongly disagree with this finding. Project staff accorded every VE issue appropriate and serious consideration and provided documented justification of each decision on the VE disposition form.

To support this finding, the report refers to documents from 1989, a period when the VE Program was being developed. By 1990, the program had been more clearly defined, and project management had evaluated the initial efforts to start the program, reviewed goals and direction, and dedicated additional project staff to the program. Documents from the formative stages of the program are not representative of later actual policies and practices.

Regarding the specifics of this finding:

- Meeting minutes were not kept because decisions and justifications for each recommendation are included in each report. Experience has proven that extensive meeting minutes are of limited value, especially in light of the costs for staff to transcribe, organize, file, and maintain them. All parties agreed that meeting minutes were not necessary.

- The project's rejection of a design recommendation from the June 1992 South Bay Interchange - Kneeland to Randolph study was not "subjective," as the report asserts. The recommendation was rejected primarily because its proposed $83 million savings was predicated on using a type of steel that is susceptible to corrosion in a seacoast environment and in areas with heavy use of de-icing road salt. The recommendation was

also rejected because it proposed using I-girders rather than box girders for the viaduct superstructure. Box girders are used throughout the United States and provide superior structural support on curved highway alignments.

This case illustrates the central fact that VE teams often make recommendations with greater emphasis on potential construction savings. But Project managers must weigh the potential savings offered by a VE recommendation with many other important costs and impacts, including:

- Maintenance
- Life cycle
- Constructibility
- Staging plans
- Traffic operations
- Urban design
- Architectural considerations

In this case, the merits of I-girders versus box girders were seriously considered by project engineering staff using a system based on the criteria above. Even though potentially more expensive, the box girder design emerged as the preferred design, thus leading to the rejection of the VE recommendation.

FINDING 5: "B/PB did not to address value engineering recommendations in a timely manner."

We acknowledge that during 1989-1990, the timeliness in addressing VE recommendations could have been improved. However, any delays encountered in implementing VE recommendations did not reduce their potential to save costs, and no opportunity to implement a recommendation was missed. Project engineers performing preliminary design were well aware of VE recommendations, since these engineers were debriefed by the VE team at the conclusion of each study.

FINDING 6: "B/PB did not provide the value engineering teams with sufficient information."

VE teams were provided with the most current information available at the time the study was performed. As noted previously, the project continued preliminary design while VE studies were carried out; thus design progress outside the VE review may have been misinterpreted as a lack of information. In fact, extensive information was provided to the VE teams, as is reflected in the VE team reports. VE workshops by their very nature stimulate divergent

viewpoints and requests for more information, and some individuals may have wished for more documents. This is expected and encouraged in the "brainstorming" atmosphere of a VE study.

FINDING 7: "Value engineering teams did not provide life-cycle cost-saving estimates for 99 percent of all value engineering recommendations."

Life-cycle costs were provided in cases where they could be credibly established. While not all recommendations necessarily have life-cycle costs, we agree that future teams will be directed to develop life-cycle costs based on applicability to a specific recommendation.

FINDING 8: "Value engineering teams provided construction cost-saving estimates for only 23 percent of all value engineering recommendations."

Construction costs do not apply to all VE recommendations. This issue was discussed at length in late 1990 by MHD, FHWA and B/PB. It was agreed that savings would be estimated where appropriate, but that construction cost alone should not be a limiting factor in a VE team's attempt to either capture ideas for improving the value and function of the design or reduce overall costs. The improved value/function and cost avoidance categories were added to the project's VE reporting system.

FINDING 9: Employing staff from Bechtel Corporation and Parsons Brinckerhoff to perform value engineering analysis compromised the program's independence.

At all times, B/PB performed VE services at the direction of MHD and FHWA. As specified in the VE program manual, B/PB's VE program manager reported directly to the MHD Manager of Value Engineering, from whom all program direction was received. As shown in the VE Program Manual, MHD's Value Engineering staff consisted of the MHD Manager of Value Engineering and the MHD Value Engineering Project Engineer.

VE teams members were selected on the basis of their expertise. The B/PB VE program manager, at the direction of the MHD Manager of Value Engineering — and independent of B/PB project management — coordinated the selection of VE candidates. Independence was maintained and project management had no opportunity to exert influence on the B/PB VE program manager. In fact, Bechtel Corporation and Parsons Brinckerhoff Quade and Douglas employees have proven to be highly critical VE team members, as evidenced by the more than 600 recommendations mentioned in your report.

Similarly, the selection of issues for VE study remains an independent process. MHD and FHWA select and approve VE topics — not B/PB. All value engineering activities are carried out with full MHD and FHWA approval. Figure 2 on page 22 should be corrected to reflect

that B/PB does not direct the VE studies of either preliminary design or project-wide criteria.

We disagree that a position fulfilling more than one role in an organization compromises independence. Part time responsibilities and multiple chains of command foster independence, provide clear lines of authority and are necessary in an environment such as VE which requires such attributes. Matrixed reporting relationships are used successfully by many large organizations which have responsibilities and/or tasks to be performed that do not require an assignment of a full time individual. We agree that these should be kept to a minimum and that the assignment responsibilities should be made to the most logical position. Independence is a key element of Value Engineering and also of Quality Assurance. Therefore it made sense to assign Value Engineering responsibilities to the Quality Assurance Manager.

FINDING 10:"Mass Highway and B/PB failed to develop detailed guidelines for ensuring that B/PB implemented the value engineering recommendations Mass Highway accepted."

This finding is highly misleading because it is based on memos and letters culled from the very preliminary stages of the VE Program in 1988 and 1989. As noted previously, project management took action in 1990 to revitalize the program and address shortcomings.

The suggestion that the project has "failed" to implement accepted recommendations is incorrect. The supporting documentation does not cite any accepted recommendations which were not implemented. Further, each of the implemented recommendations was audited in accordance with the program approved by MHD and FHWA.

FINDING 11:"Contrary to its own guidelines, B/PB did not provide an adequate audit function of the Value Engineering Program."

In accordance with the guidelines of the VE program manual, an audit of every item is not required. All audit decisions were approved by MHD and FHWA as part of the applicable work program negotiations.

Regarding the timeliness of closeout audits, they only began after the VE Program Manager was informed that all issues for a particular study had been resolved.

FINDING 12:"The project did not follow its plan to conduct studies during the final design stage."

The decision to eliminate VE studies at 70 percent design was deliberately taken since value engineering yields the most benefit and potential cost savings when conducted in the early preliminary design stage as noted in the report and in this response. Project VE managers determined that VE exercises at the 70 percent level, while useful, would be of lesser benefit

than selected studies at the 30 percent level. Therefore, with full cognizance of all parties, MHD and FHWA deleted the 70 percent design study portion of the VE program after 1989 and instead moved ahead with selected VE reviews at the 30 percent design level, as well as other projectwide topics. This change was incorporated in Revision O of the VE Program manual, which was reviewed and approved by MHD and FHWA.

CONCLUSION AND RECOMMENDATIONS

We appreciate the opportunity to review and comment on this draft report. We agree that the VE Program could have been more timely in making decisions regarding the implementation of VE recommendations. But we must reiterate: the program's slow start did not cause the project to miss the actual implementation of any recommendation.

We hope the final report will reflect the fact that the Central Artery/Tunnel Project's VE Program took advantage of the most significant opportunities available to improve design and reduce costs. We disagree with the report's claims that the VE Program experienced inadequate planning and poor management, and we find no evidence in the report to support these claims. To date, the VE Program has saved an estimated $320 million. We look forward to continued substantial savings as we enter the construction contractor proposal phase of the Value Engineering Program.

1. Eliminate B/PB from its current pivotal role in managing the Value Engineering Program

Mass Highway is in charge of the Value Engineering Program and makes all decisions related to the Value Engineering Program. As an extension of Mass Highway, B/PB performs administrative Value Engineering program tasks. As such, B/PB does not have a pivotal role when it comes to Value Engineering.

In the past, we have included non-B/PB home office personnel in the Value Engineering process. Where we can readily accomplish this and it makes sense to do so, we agree to go outside B/PB when selecting Value Engineering team members.

2. Conduct a comprehensive Value Engineering program review.

We agree there is value in performing this review. The project is currently performing this review by re-evaluating decisions made on previous Value Engineering recommendations.

At the 70% level, we will do Value Engineering studies where it makes sense to do so. Our experience is that Value Engineering at this stage has minimal value. In our case, 70% means that structural design is 100% complete. A more effective mechanism we use is peer review. Peer review consists of a mixed team of outside technical experts reviewing a portion of the design, focusing on technical proficiency.

3. Remold VE program to assure its independence and usefulness as a cost cutting tool.

We agree to continue our focus on these issues. As outlined in Item No. 1, Mass Highway and B/PB's roles are clear.

3:19pm December 6, 1994

List of Attachments to the Project's Response
(prepared by the Office of the Inspector General)

1. Federal Highway letter to MassHighway, dated May 23, 1991.

2. MassHighway letter EN-7, EN-1.14.2, 091-0896, dated April 17, 1991.

3. MassHighway letter EN-7, EN-1.14.2, 091-0151, dated January 25, 1991.